

16.—Distribution and function of resins and glandular hairs in Western Australian plants

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Abstract

The taxonomic distribution of glandular hairs and resins is documented. Resinous plants are prevalent in some genera within the Mimosaceae, Euphorbiaceae, Sapindaceae, Boraginaceae, Dicrastylidaceae, Lamiaceae, Myoporaceae, Solanaceae, and Goodeniaceae. With few exceptions there is a correlation between surface resin and glandular hair distribution. The genus *Eremophila* is discussed in detail. Resins may have a function in reducing water loss by increasing resistance to cuticular transpiration and by reducing leaf temperature by increasing radiation reflectance from the leaf.

Introduction

A systematic treatment of glandular hairs and leaf resins in Western Australian plants has not been attempted previously. Interest in resin formation in some species (Dell and McComb 1975) and the possibility that plant resins may be of use in difficult taxonomic groups (Dell 1975) led to an investigation of the relationship between glandular hairs and surface leaf resins.

The significance of resins in plants has remained an enigma, proposed functions having little experimental proof. In *Beyeria viscosa* the distribution of the resin on the leaf surface varies according to leaf maturity and is closely tied to the early stages of glandular hair formation (Dell and McComb 1974). Incidental observations that this pattern of resin distribution could be altered by temperatures not lethal to some plants, led the author to evaluate the possible importance of the resin in increasing reflectance of light from the leaves. Pearman (1966) has indicated the importance of surface features such as hairs and scales in increasing reflectance. Slatyer (1964) and Waggoner (1966) have noted that the possession of shiny leaf surfaces could probably reduce the heat load by 10–15% under stress conditions. This factor together with the high heat resistance of some Western Australian plants (e.g. up to 59°C., Grieve and Hellmuth 1968) could be of importance to plants subject to irregular and often prolonged droughts.

Distribution of glandular hairs and resins

Collections of plants bearing resins and/or glandular hairs were made in the field. Voucher specimens are housed in the University of Western Australia (UWA) (see Appendix I). Sections

of fresh, preserved and in some cases, dried herbarium material, were examined and types of trichomes and their distribution recorded. The results are summarized in Table 1 and a few of the trichome types are illustrated in Fig. 1.

It is apparent that the majority of resinous genera are either woody or herbaceous dicotyledons. Nearly all plants with external resinous exudations bear glandular hairs beneath the exudate. It can be assumed that the glandular hairs in these species are implemented at least in resin secretion and perhaps also in resin synthesis. Exceptions include some taxa of the Myrtaceae, Celastraceae, Fabaceae, Poaceae and Haemodorumaceae. The secretion sites of sticky exudates in some species of *Calytrix*, *Pileanthus*, *Psammomoya* and *Burtonia* need to be investigated further. There is a possibility that epidermal cells have a glandular function in these genera.

Not all plants with glandular hairs secrete resins (Table 1): some glandular hairs are pigmented (e.g. *Diplopeltis*), others produce volatile oils (e.g. *Anthocercis*), mucilages etc. In some plants glandular hairs are confined to the inflorescences (e.g. members of the Proteaceae); in others the trichomes are confined to the leaves, phyllodes and stems (e.g. *Acacia*) or may occur on both the leaves and the flowers (e.g. *Eremophila*, *Stylidium*).

Western Australian plants with resinous sheets are prevalent in some genera within the Mimosaceae, Euphorbiaceae, Sapindaceae, Boraginaceae, Dicrastylidaceae, Lamiaceae, Myoporaceae, Solanaceae and Goodeniaceae.

The genus *Eremophila* is an example that illustrates the prevalence of resinous species in dry habitats. Approximately 70% of the species occur in Western Australia where they are most abundant in the north and interior regions of the State. About 43% of these have resinous leaves and stems. The resin may exist as a continuous varnish over the leaves (e.g. *E. fraseri*, *E. serrulata*), be confined to one surface (e.g. *E. latrobei*), or exist as isolated patches (e.g. *E. angustifolia*, *E. duttonii*). This variation is reflected in the amount of resin expressed as a percentage of leaf dry weight in Table 2. Species with high resin yields usually have continuous sheets of resin, at least on the young leaves.

Surface resins in all *Eremophila* species are produced by glandular hairs. The nearly universal glandular hair has a short stalk with up to eight cells in the head. Many of the species

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Table 1

Occurrence and taxonomic distribution of glandular hairs and resinous plants in Western Australia. Voucher specimens are cited in Appendix I.

Family	Examples	Distribution of glandular hairs	Surface features*
Poaceae	<i>Triodia</i>	?	resinous
Orchidaceae	<i>Elythranthera</i> <i>Caladenia</i>	leaves and stems inflorescences	— —
Liliaceae	<i>Agrostocrinum</i>	inflorescences	—
Haemodoridae	<i>Conostylis</i>	?	resinous leaf edges
Proteaceae	<i>Adenanthos</i> <i>Grevillea</i>	inflorescences inflorescences	viscid viscid
Chenopodiaceae	<i>Chenopodium</i>	leaves and stems	—
Nyctaginaceae	<i>Boerhavia</i>	leaves and stems	—
Gyrostemonaceae	<i>Didymotheca</i>	leaves and stems	resinous
Capparidaceae	<i>Cleome</i>	leaves, stems, and inflorescences	viscid
Droseraceae	<i>Drosera</i>	leaves and stems	specialized for insect-ivory
Byblidaceae	<i>Byblis</i>	leaves and stems	specialized for insect-ivory
Mimosaceae	<i>Acacia</i>	young leaves	viscid, resinous
Caesalpiniaceae ..	<i>Cassia</i>	rare on leaves	—
Fabaceae	? Genus	leaves, stems and inflorescences	resinous
	<i>Burtonia</i>	?	resinous
Tremandraceae	<i>Tetratheca</i>	rare on young stems	—
Euphorbiaceae ..	<i>Bertya</i>	leaves and stems	resinous
	<i>Beyeria</i>	leaves and stems	resinous
	<i>Rhinocarpus</i>	leaves and stems	viscid
Celastraceae	<i>Psammomoya</i>	?	resinous stems
Sapindaceae ..	<i>Diplopeltis</i>	mainly inflorescences	—
Malvaceae	<i>Dodonaea</i>	leaves and stems	resinous
	<i>Abutilon</i>	leaves and stems	—
	<i>Hibiscus</i>	leaves and stems	rarely viscid
Myrtaceae	<i>Eucalyptus</i>	rare on leaves	?
	<i>Calytrix</i>	?	viscid
	<i>Pileanthus</i>	?	viscid
Plumbaginaceae	<i>Plumbago</i>	inflorescences, fruits	± viscid
Boraginaceae	<i>Halganina</i>	leaves and stems	resinous
Dicrastylidaceae	<i>Chloanthes</i>	leaves and stems	—
	<i>Cyanostegia</i>	leaves and stems	resinous
	<i>Dierastylis</i>	leaves and stems	—
	<i>Lachnostachys</i>	leaves and stems	—
	<i>Newcastelia</i>	leaves and stems	viscid, resinous
Avicenniaceae	<i>Pityrodia</i>	leaves and stems	—
	<i>Avicennia</i>	leaves and stems	specialized for salt secretion
Lamiaceae	<i>Hemigenia</i>	leaves and stems	—
	<i>Prostanthera</i>	leaves and stems	resinous
Solanaceae	<i>Anthocercis</i>	leaves and stems	resinous
	<i>Nicotiana</i>	leaves, stems and inflorescences	viscid
Scrophulariaceae	<i>Gratiola</i>	leaves and stems	viscid
	<i>Stemodia</i>	leaves and stems	viscid
	<i>Verbascum</i>	leaves, stems and inflorescences	—
Orobanchaceae	<i>Veronica</i>	rare on leaves	—
Lentibulariaceae	<i>Orobancha</i>	stems	viscid
	<i>Utricularia</i>	rare on traps	specialized for insect-ivory
Myoporaceae ..	<i>Eremophila</i>	leaves, stems and inflorescences	resinous
Goodeniaceae	<i>Myoporum</i>	leaves and stems	resinous
	<i>Calogyne</i>	leaves and stems	—
	<i>Cooperhookia</i>	leaves and stems	resinous
	<i>Goodenia</i>	leaves and stems	viscid, resinous
Stylidiaceae	<i>Scaevola</i>	leaves and stems	—
	<i>Stylidium</i>	inflorescences, rare on leaves	viscid
Asteraceae	<i>Brachycome</i>	leaves and stems	—
	<i>Helichrysum</i>	leaves and stems	—
	<i>Helipterum</i>	leaves and stems	—
	<i>Ixiolaena</i>	leaves and stems	—
	<i>Olearia</i>	leaves and stems	resinous
	<i>Pluchea</i>	leaves and stems	—

* resinous—leaf has a continuous or broken layer of resin.
viscid—sticky; resin, when present, confined to glandular hairs.
where the glandular hairs do not produce viscid or resinous material this is indicated as —.

which do not appear resinous, for example species with a dense tomentum of stellate or branched hairs, also have an understorey of stalked glandular hairs (Fig. 1). Large branched hairs with some glandular tips are scattered through the tomentum of similar but non-glandular trichomes of *E. leucophylla* and *E. turtonii*.

Distribution of resin on the leaf surface

Whilst observing *Beyeria* leaves under bright lights it was noticed that the surface of the leaf changed from matt-like to mirror-like in appearance (Fig. 2). It was possible to see reflection of images from the mirror surface. Leaves continued to grow after this transformation and presumably were not affected internally by the additional radiant heat. When heated in an oven it was found that at 55°C. the abaxial sheet of resin coalesces within two minutes. At 51°C. the youngest leaves form a sheet in about the same time but the half-expanded leaves take up to five minutes to achieve the same resin flow. Twelve minutes exposure at 44°C. causes the resin to run on young and mature leaves as at the higher temperatures. Resin, removed from the leaf surface, melts at about 48°C. to form a thick, viscous liquid.

The effect of radiant heat on the leaf surface causes the resin to become mobile and, on the younger leaves, the resin flows together on the abaxial surface and forms a continuous sheet with a smooth surface. On mature leaves the resin droplets are widely spaced and the effect of heat causes the resin to coalesce into 'rivers'.

The composition of the resin on the leaf surface is probably determined by genetic factors whereas the amount of resin on the leaf surface is a combination of genetic and environmental factors and is closely related to the distribution and abundance of glandular hairs. The distribution of the resin on the leaf surface is dependent on such factors as resin composition, amount of resin/unit area and surface topography.

If the resin is of adaptive value to the plant, it might be expected that plants growing under some stress conditions would produce more glandular hairs and hence more resin than plants growing under mesophytic conditions. New shoots of plants transferred from the field to glasshouses were always softer and had fewer glandular hairs than those at the time of removal.

Reflectance of light from leaves

The technique of Pearman (1966) was used. A Bausch and Lomb Spectronic 20 colorimeter with an integrating sphere-reflectance attachment was used for measuring the total reflected visible radiation from leaves. The colorimeter produces wavelengths from 340 to 620 nm in bands of 20 nm width, and these were directed onto the leaf with an angle of incidence of 0°. The reflectance spectrum from *Beyeria* leaves produced a maximum at 560 nm for both surfaces. Heated leaves showed a small increase in total reflectance especially towards 540 nm. However, for any one wavelength the difference was less than 5%. Removal of resin from the

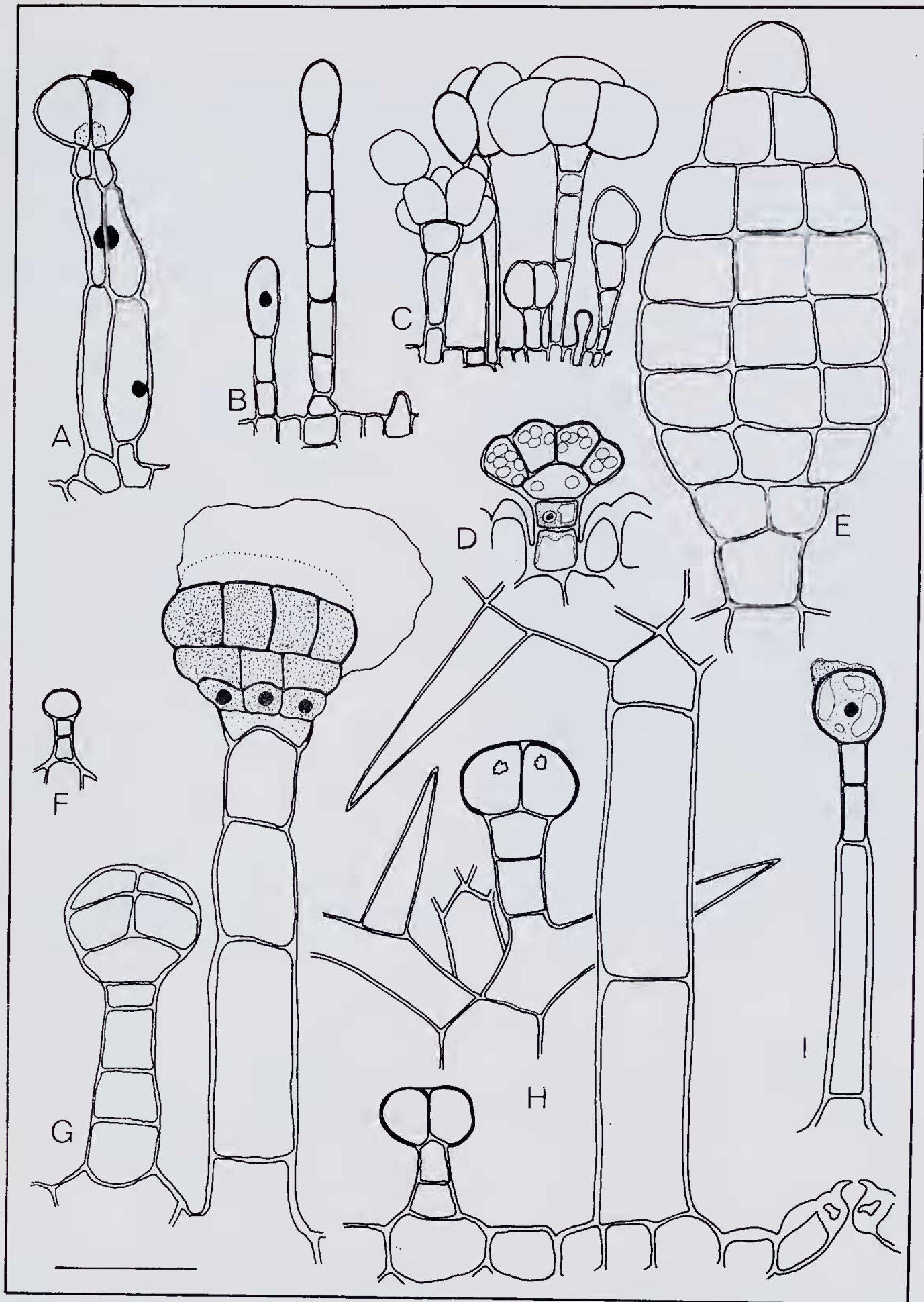


Figure 1.—Glandular hairs of some of the genera referred to in Table 1. A.—*Helichrysum rosea*. B.—*Grevillea eriostachya*. C.—*Acacia aneura*. D.—*Acacia glutinosissima*. E.—*Anthocercis littorea*. F.—*Scaevola canescens*. G.—*Scaevola glandulifera*. H.—*Eremophila leucophylla*, stellate and shortly stipitate glandular hairs are shown. I.—*Pityrodia bartlingii*. Length of bar $50\mu\text{m}$.

leaf surface of *Eremophila fraseri* caused a considerable reduction in total reflectance from the leaf (Fig. 3). An increase in reflection of light by the resin layer decreases the amount entering the leaf and subsequently being absorbed.

It was originally thought that the mirror-like surface would reflect more light than the unheated surface. Reflectance from a surface, as opposed to reflectance from within a surface, is dependent on surface features alone. When

measuring total reflected light from a surface with an integrating sphere (see above) the specular (or mirror) reflectance could be close to diffused reflectance depending on the angle of incidence. The control *Beyeria* leaves have irregular-shaped resin deposits and for low angles of incidence, on leaves naturally held towards the vertical, a considerable amount of diffused reflectance could be directed into the leaf. The distribution and optical properties of the resin can be compared with glaucous and non-glaucous eucalypt leaves where the orientation and type of wax deposits affect the amount

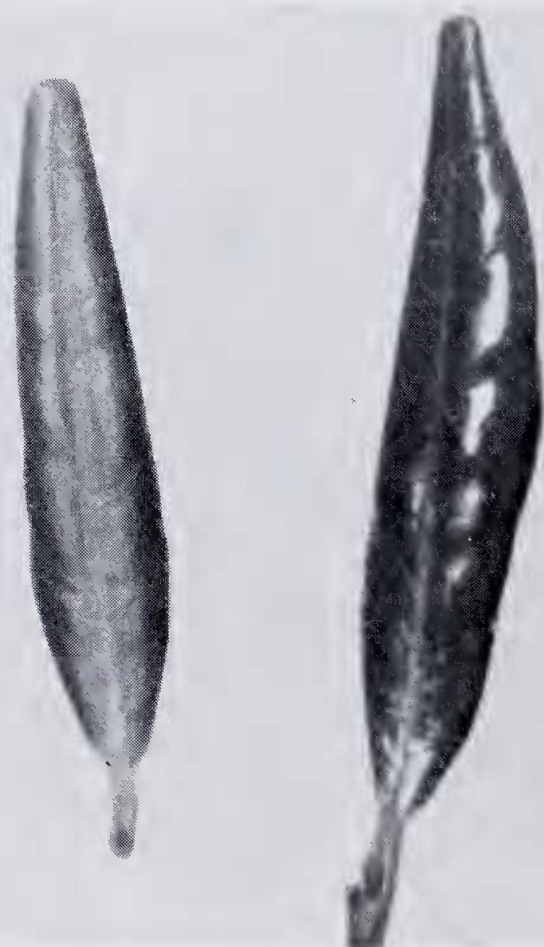


Figure 2.—Effect of heating on the appearance of *Beyeria* leaves. Control is on the left.

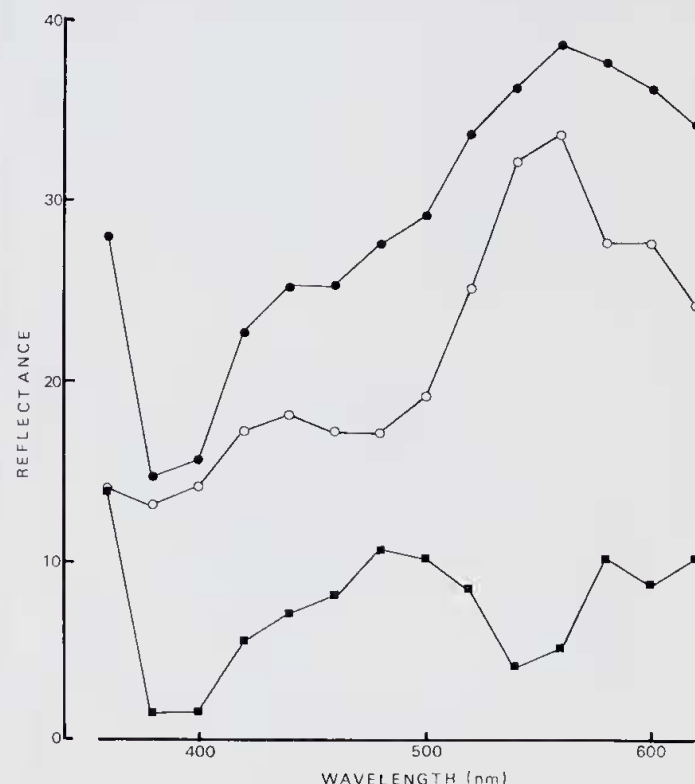


Figure 3.—Effect of resin on the reflectance of light from *Eremophila* leaves. (●—abaxial surface, ○—abaxial surface after resin wash, ■—difference between reflectance spectra of control and washed leaf. The graphs are for one leaf. Reflected radiation is expressed as a percentage of the reflectance from magnesium carbonate.)

Table 2
Resin yields of some *Eremophila* species

Species	Locality	Collection No.	Resin (% leaf dry wt.)	Distribution of resin on leaf surface
<i>alternifolia</i>	Sandstone	1015	4.5	isolated patches
<i>decipiens</i>	Boulder	1060	18	sheet
<i>deunsteri</i>	Norseman	1066	10	broken sheet
<i>drummondii</i>	Boulder	1058	17	sheet
<i>duttonii</i>	Wiluna	1036	8	isolated patches
<i>fraseri</i>	Yalgoo	56	17	sheet
<i>foliosissima</i>	Agnew	1025	22	sheet
<i>georgei</i>	Agnew, Leonora	1022, 1051	17.5	sheet
<i>granitica</i>	Sandstone, Leonora	1013, 1048	29.5	sheet
<i>interstans</i>	Boulder	1057	22	sheet
<i>latifolia</i>	Agnew	1024	18	sheet
<i>metallicorum</i>	Leonora	1046	18	broken sheet
<i>miniata</i>	Menzies	1052	7	isolated patches
<i>platycalyx</i>	Barwidgee Station	1038	21	sheet
<i>saligna</i>	Norseman	1065	3	scarce over glandular hairs
<i>serrulata</i>	Leonora	1078	15	sheet
<i>scoparia</i>	Payne's Find, Boulder	1008, 1055	1.5	not resinous
<i>willisii</i>	Agnew	1027	12	broken sheet

of light reflected from the leaf (e.g. Cameron 1970). The surface construction of leaves can be important in the reflection of wavelengths other than those measured above. Gates and Tantraporn (1952) indicate that 80% or more of the infrared radiation is effectively reflected from the outer epidermal surfaces. Wong and Blevin (1967) showed that surface hairs and dry vesicular tissues were responsible for slightly higher infrared reflectances in several species. Surface features were shown by Pearman (1968) to reflect an appreciable proportion of the visible spectrum.

The distribution of the resin over the leaf surface is important if it is to be considered that the resin has a function in reducing water loss. Reduction in water loss by resins could be achieved in two ways. Firstly, the presence of a sheet of resin over the leaf surface must increase resistance to cuticular transpiration. Gardner (1968) considered that resinous leaf coverings in species of *Eremophila* protect the leaves from the drying influence of wind. Secondly, the presence of resin does not qualitatively alter the wavelengths of light available to photosynthesis though it may reduce the amount of light entering the leaf. e.g. in *Eremophila*. In this way transpiration could be reduced by a slight lowering of leaf temperature.

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Appendix 1

Voucher specimens

Except where stated otherwise all specimens are housed in the University of Western Australia and specimens are cited by accession numbers.

Triodia pungens 2203; *Elythranthera brunonis* 2202; *Caladenia discoidea* 2201; *Agrostocrinum scabrum* 2197; *Conostylis aurea* 2196; *Adenanthos meissneri* 2199, *A. venosa* 2200; *Grevillea criostachya* 2062, *G. excelsior* 2198, *G. petrophiloides* 2052; *Chenopodium plantaginellum* 2195; *Boerhavia repandra* 2194; *Didymotheca thesioides* 2193; *Cleome viscosa* 2192; *Acacia denticulosa* MURD 27, *A. glutinosissima* MURD 26, *A. kempeana* 2190, *A. ramulosa* 2189, *A. rossei* 2053, *A. tetragonophylla* 2188; *Cassia phyllodinea* 2180, 2181, 2182, 2183; *Burtonia scabra* 2179; *Beyeria drummondii* 2177, *B. leschenaultii* 2176; *Ricinocarpos velutinus* 2178; *Psammomoya choretroides* 2048; *Diplopeltis huegelii* 2175; *Dodonaea attenuata* 2206, *D. boroniaefolia* 2205, *D. bursartifolia* 2208, *D. caespitosa* 2207, *D. concinna* 2215, *D. filifolia* 2212, *D. inaequifolia* 2209, *D. laraeoides* 2210, *D. piniifolia* 2214, *D. ptarmicifolia* 2213, *D. stenozyga* 2063, *D. viscosa* 2211; *Eucalyptus citriodora* MURD 28; *Calytrix glutinosa* 2173; *Pileanthus filifolius* 2172; *Plumbago zeylanica* 2171; *Halgania cyanea* DELL 127 (PERTH), *H. lavendulacea* DELL 167 (PERTH), *H. viscosa* DELL 84 (PERTH), *Halgania* sp. DELL 113 (PERTH); *Chloanthes coccinea* 2168; *Cyanostegia angustifolia* 2054, *C. lanceolata* 2055, *C. microphylla* 2056; *Dicrastylis micrantha* 987; *Lachnostachys bracteosa* 2170, *L. cliftonii* 2169; *Newcastelia viscida* 2057; *Pityrodia bartlingii* 2167; *Hemigenia divaricata* 2166; *Prostanthera eckersleyana* 2164, *P. grylloana* 2165; *Anthocercis aromatica* 2159, *A. littorea* 2217, *A. viscosa* 2610, DELL 1002; *Nicotiana occidentalis* 2161, *N. rosulata* 2162; *Verbascum virgatum* 2163; *Eremophila alternifolia* 2086, 2087, *E. angustifolia* 2088, 2090, *E. clarkei* 2091, 2098, *E. compacta* 2073, *E. decipiens* 2103, 2105, 2109, *E. delisseri* 2070, *E. drummondii* 2100, *E. duttonii* 2069, 2102, *E. eriocalyx* 2072, 2110, *E. exilifolia* 2111, *E. foliosissima* 2112, 2113, 2114, *E. fraseri* 2058, 2060, 2061, *E. freelingii* 2068, *E. georgii* 2115, 2119, 2125, *E. glabra* var. *viridiflora* 2050, *E. granitica* 2126, 2127, *E. hughesii* 2128, *E. interstans* 2075, *E. latifolia* 2131, *E. latrobei* 2065, 2130, *E. leucophylla* 2134, *E. longifolia* 2132, 2133, *E. macmilliana* 2066, 2135, 2136, *E. margarethae* 2071, *E. miniata* 2059, *E. oppositifolia* 2138, 2139, *E. platycalyx* 2140, 2141, *E. platythamnus* 2142, *E. punicea* 2074, *E. pustulata* 2143, 2144, *E. ramosissima* 2146, *E. saligna* 2147, *E. scoparia* 2051, *E. serrulata* 2148, 2149, *E. spathulata* 2150, *E. subfloccosa* 2151, *E. virens* 2049, *E. woollisiana* 2152, 2153, *E. youngii* 2067; *Myoporum deserti* 2158; *Calogyne berardiana* 2156; *Coopernookia polygalacea* 2085; *C. strophilata* 2080; *Goodenia glandulosa* 2084, *G. pinatifida* 2079, *G. viscida* 2081; *Scaevola glandulifera* 2077, *S. restiacea* 2076; *Stylidium spathulatum* var. *glandulosum* 2204; *Brachycome* sp. 2155; *Olearia muellei* 2047.

